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Proceedings of the American Society of Civil Engineers

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Journal of the
CONSTRUCTION DIVISION
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CONSTRUCTION OF MORRISON BRIDGE[a]

By R. D. Bane,[1] F. ASCE

SYNOPSIS

Late in 1958, Multnomah County completed a new bridge in Portland, Oregon, at a cost of over $13,000,000 to cross the Willamette River and to connect through extensive approaches to downtown streets. This article reports on the construction of the 760-ft river bridge and its approach systems.

The new Morrison Bridge over the Willamette River was opened to the traveling public in downtown Portland, Oregon, during May, 1958. Four months later the removal of the old Morrison Street Bridge from the site ended the 3-yr period required for construction of this modern bridge and approaches. This article presents a general description of the construction phase of the Morrison Bridge Project and discusses in detail a few selected features of construction.

Briefly, the project consists of a three-span river crossing, 760 ft in length, together with approach systems on each river bank. The river crossing has two deck truss approach spans and a double-leaf bascule span with a 220-ft clear horizontal opening. A six-lane roadway, 78 ft wide between curbs,

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[a] Presented at the June 1958 ASCE Convention in Portland, Oregon.

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with 5-ft sidewalks are provided on the river bridge. The west approaches span across three cross streets to accommodate traffic to and from the downtown area and major arterial streets. The east approach system, extending approximately 1,900 ft from the east river bank, has off and on connections to the nearby east industrial area and carries main bridge traffic on two three-lane, one-way, elevated approaches over five cross streets to connect with U.S. Highway 99E.

Late in 1955, the pier contractor mobilized marine equipment at the site for the river substructure units and proceeded with the driving and loading of test piles. Additional equipment and materials were soon assembled at the site by the contractor in preparation for construction of Pier 1, at the west bank, Piers 2 and 3 located in the center, and Pier 4, near the east bank of the river. Pier foundations were built one at a time to permit maximum reuse of cofferdam materials. The contractor made Piers 2, 3, and 4 easily accessible to workmen, equipment, and supplies by installing a timber trestle between Pier 2 and the east river bank. Pier 1 was within reach of land-based equipment on the west harbor wall.

Construction of Pier 2 (Figs. 1 and 2), below the surface of the river, was probably the most hazardous undertaking on the entire project. Briefly, this is how the contractor proceeded with the building of this deepest bascule pier:

The two lowest rings for the cofferdam's internal framing were assembled on a barge with considerable overhang along the sides of the barge. After the barge was floated to the pier location, steel guide piles were driven at each corner for suspending the framing rings. The barge was then partially filled with water and towed away from the suspended frame. Next, the two upper framing rings were assembled in place as the entire internal framing unit was slowly lowered into position. Z-32 steel sheet piles were driven around the frame to tip elevation of -80 and top elevation of +15, Portland Datum. El. 3.2 equals low-water elevation according to this datum. The sand and gravel in the cofferdam was excavated by clamshell bucket down to El. -75. One hundred fifty four 14-in. bearing piles, at 102 lb per ft, were driven to tip elevation of -119 inside the cofferdam limits. Piles were driven under water with a McKiernan-Terry 10S hammer which delivers 32,500 ft-lb of energy per blow. Next, a concrete seal course, 26 ft deep, was poured into the cofferdam. The 6,200 cu yd in this seal course were placed in 34 hr of continuous pouring. Transit-mix trucks delivered this concrete over the timber trestle to the pier site where it was conveyed by gravity to 9-in diameter tremies into the seal. After the seal course had been in place for 7 days, the water was pumped from within the cofferdam. Two 12-in., 125 hp, and two 10-in., 50 hp electric pumps were used in initial unwatering; but after drawdown was complete, one 10 in. pump easily discharged all run-in which was less than 2,000 gal per min. A 10-ft depth of concrete footing was next constructed within the dry confines of the cofferdam and then shaft construction proceeded. After shafts were built to El. 25 and forms were removed, pumping ceased and water rose to river level within the cutoff wall. Steel sheet piles were extracted and the internal bracing frame was removed and dismantled. No difficulty was experienced with the frame which was made up of 24-in WF walers, timber posts, and timber struts. In areas where struts passed through concrete shafts, steel beams were used and left in place. Cofferdams were constructed by a similar procedure for Piers 1, 3, and 4.

As each of the river piers was constructed above the level of the river, progress was accelerated and the work was vigorously pressed by the con-

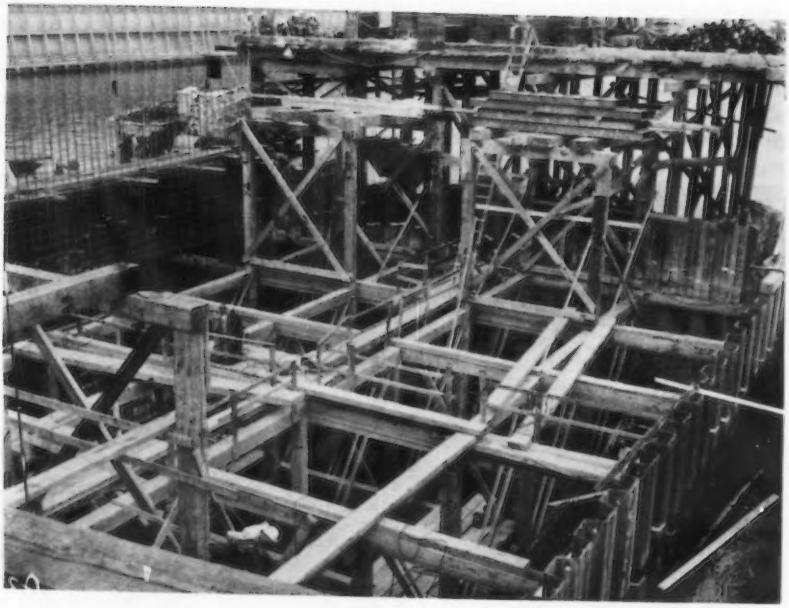

FIG. 1.—FRAMING IN COFFERDAM FOR BASCULE PIER 2

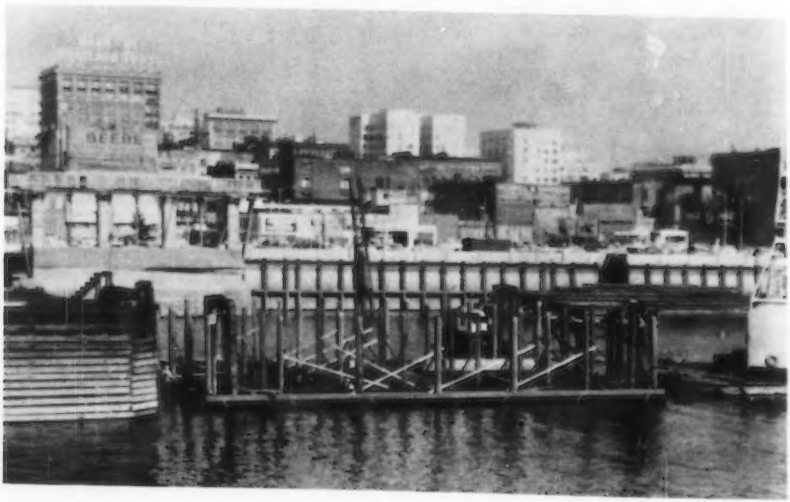

FIG. 2.—COFFERDAM FRAM IS LOWERED INTO POSITION FOR PIER 2

tractor until completion (Fig. 3). The river piers contract was completed slightly later than the specified date. However, the piers were ready to receive structural steel superstructure only 19 days later than originally required by the contract.

Nearly 60,000 cu yd of concrete were incorporated in various portions of bridge. Mixes at desired consistencies were designed in a commercial laboratory and adjusted in the field to meet conditions of placement. In general, test

FIG. 3.—BRIDGE UNDER CONSTRUCTION WITH BASCULE PIER 3 IN FOREGROUND

cylinders for mixes averaged at least 30% above minimum required strengths. Cement factors were always held to the specified minimum. Concrete aggregates were dredged from the Willamette River and stockpiled at a batching plant about 3 miles upstream from the project site. Transit mixers were used and the time of travel from batcher to the structure averaged 10 min. Two-way radio contact between plant dispatcher and trucks resulted in maintaining excellent control of consistency under all conditions of placement.

Construction of the river piers was six months along in May, 1956, when contracts were awarded on the river superstructure and east approaches portions of the project. Two months later a contract for the west approaches was awarded. Progress on both east and west approaches proceeded approximately as anticipated, and each was ready for vehicular traffic on the specified contract dates. While the construction of the river spans may seem more spectacular, a relatively large part of the engineer's field forces' time was required in supervising the work on the approaches. The necessity of keeping streets open for the public and business concerns contributed to the difficulty of this work.

Substructure work on the approaches was completed according to schedule. During the foundation construction period, the all-welded girders were being fabricated for use as superstructure stringers. Stringers were yarded after fabrication, then transported to the bridge site on trucks and trailers. At the site, steel stringers were erected with truck cranes. None of the stringers exceeded 26 tons in weight and field erection presented no unusual problems or difficulty.

The contractor devised an unusual concrete-finishing machine for use on the straight-run deck of the east approaches. A Clary roller finishing machine was adapted to meet the job requirements. Rails were installed 42 ft apart to accurate elevations along the sides of the deck forms upon which the machine was operated. This modified finishing machine made the initial strike-off and finished the slab to the extent that only a skip float was needed ahead of the brooming operation. In consolidating the concrete mix, the usual type of internal vibrator was used to supplement the 9-in. vibrating pipe on the machine.

Shortly after the award of the superstructure contract was made, a nationwide steel strike resulted in a subsequent 6-month delay in receipt of fabricated structural steel at the site. Although this material was late in arriving, men and machinery worked such hours, and were used to such good effect on the superstructure, that it was possible to open the bridge to traffic only $2\ \frac{1}{2}$ months later than was originally scheduled.

Structural steel was fabricated in Gary, Ind., and Memphis, Tenn. It was unloaded in a Portland yard from railway freight cars, near a riverside dock about $\frac{3}{4}$ mile upstream from the bridge site. Bascule leaf members were hoisted into place with a 50-ton scow derrick after fabricated pieces were brought to the site on barges (Fig. 4). The leaves were erected in down position, starting at the counterweights and cantilevering from the trunnion beam toward the center of the span. Timber bents temporarily supported the counterweight frame from the pit floor until it was filled with concrete. Erection loads were approximately balanced on the trunnions by placing steel and counterweight concrete alternately. Side spans, each 90 ft wide by 207 ft long, and weighing 450 tons, were erected on barges at the riverside dock and floated into position as single units. Two 300-ton barges were used, one under each truss, using temporary falsework bents of proper height to meet the bridge seats. A portion of the end panel next to the shoreline was erected after each span was in exact position in order to allow for adequate clearance while floating into approximate position. Barges were then lowered by flooding with water and at the same time the spans were raised vertically on jacks. As barges came clear they were towed from the site.

Lightweight aggregate (expanded shale) was mixed in combination with medium fine river sand and $\frac{1}{4}$ in. pea gravel to produce concrete for side span decks with dry weight of 103 pcf. With a cement factor of 7 sacks per cu yd, specimen cylinders showed compressive strengths in excess of 2,900 psi for 7-day breaks and over 4,000 psi for 28-day breaks.

Experienced millwrights installed and adjusted all machinery for the bascule spans to exceptionally good field tolerances. Racks were each completely assembled in the manufacturer's plant in Portland, carefully inspected, and scribed with the pitch circle. Sections were then match-marked, disassembled, and shipped to the structural steel fabricator. Racks were shop-positioned to the truss assembly and holes for connection were drilled undersize in the truss members opposite those in the rack segments. This precaution allowed for a final adjustment in the field after erection was complete and counterweights were placed. Final adjustments in the field up to 3/16 in.

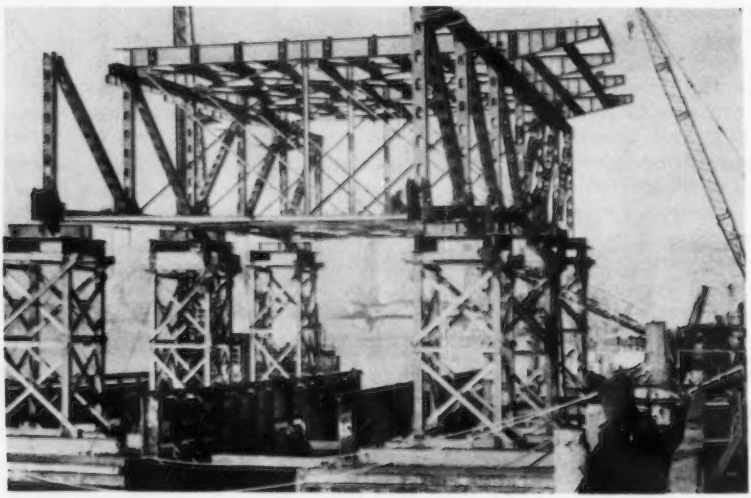

FIG. 4.—DECK TRUSS ON BARGES

were made on temporary erection bolts which were undersized, preparatory to reaming holes in the rack and truss to receive the full diameter of the specified turned bolts.

No difficulty was experienced in the electrical check-out of the control system. A prescribed procedure was followed in adjusting the center of gravity of bascule leaves to the desired position near trunnion centerline. Changes in the number of portable counterweight blocks in the upper and lower counterweight galleries were used to make this adjustment.

Late in 1956, officials for the County decided to provide for a traffic detour across the Willamette during the latter 9 months of the project construction period. Otherwise, the conflict in alienment of the old and new bridge would have necessitated closing the crossing to the public during this period. This decision required the construction of a detour which utilized the adjacent

Morrison Street Bridge in place except for its east span which was angled to the upstream (Fig. 3). Traffic was routed from the east river bank around and under the approach spans to Water Avenue. Contract cost for building and maintaining the detour was $70,000. An average of 16,000 vehicles per day was accommodated over the old modified structure after the detour was opened to travel in June, 1957 (Fig. 5). The Morrison crossing was closed to vehicles a total of 6 days while the east end of the old east span was floated by barge to its new location and necessary end connections were being made.

Construction of the new Morrison Bridge was certainly well supervised by sidewalk superintendents. The proximity of the downstream sidewalk of the old bridge to the new work provided spectators with a veritable "seat in the front row." Observers gathered there daily to watch the bridge rise from the depths of the river to take its arched and graceful form across the water.

This bridge is the third to be built at this site. The first was a timber bridge built in 1883, and was the first bridge over the Willamette in Portland.

FIG. 5.—MORRSION BRIDGE AND APPROACHES (WEST APPROACHES ARE ON LEFT)

In those days, as is the case today, traffic control was necessary. The County Court put up a sign limiting horse-drawn vehicles to a walk and processions to rout step.

The second bridge was built in 1905, without interrupting vehicular traffic. That bridge is now replaced by the new bridge.

While this new bridge and its approaches symbolize advancement in bridge design, it, too, is destined to become obsolete. Perhaps this obsolescence will appear in the steel grid floor on the bascule span. Certainly an open floor would not be suitable to the suggested car of the future which glides along on air pads instead of wheels.

ACKNOWLEDGMENTS

Sverdrup and Parcel, Inc., and Moffatt, Nichol and Taylor, project design engineers, also supervised the construction for the sponsor, Multnomah County. Competitive bids for the work were received by the County and the four contracts were awarded as follows:

1. River Piers - Manson Construction and Engineering Co., $1,908,516. Awarded October, 1955.
2. River Superstructure - American Bridge Division, U.S. Steel Corp., $2,270,443. Awarded May, 1956.
3. East Approaches - Kuckenberg Construction Company, $2,971,571. Awarded May, 1956.
4. West Approaches - Donald M. Drake Company, $1,178,360. Awarded July, 1956.

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PHOTOGRAPHIC ANALYSIS FOR CONSTRUCTION OPERATIONS

By John W. Fondahl,[1] M. ASCE

SYNOPSIS

The problems of applying methods-study techniques to construction operations are reviewed. Based on these problems, certain requirements for a successful analysis method are developed. A method that meets these requirements is presented.

METHODS STUDY APPLIED TO CONSTRUCTION-PROBLEMS AND REQUIREMENTS

The term "methods study" is used here in the more limited sense, implying formalized procedures such as stop-watch time studies, micromotion studies, and data analysis by process and multiple-activity charts. Utilizing such procedures, methods study has undeniably made tremendous contributions to present-day manufacturing processes. However it has contributed surprisingly little to one of the largest, most important manufacturing industries, namely construction.

Construction management claims that its problems differ from those of other manufacturing industries because it is required to manufacture:

(1) a custom product
(2) that is built-in-place
(3) by a non-permanent work force
(4) performing non-repetitive operations.

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When it is suggested that methods study and other industrial engineering techniques be applied to construction, these factors are cited as inherent obstacles. Furthermore, it is generally claimed that the problems of both field execution and office estimating fall more nearly into the realm of art rather than science. Proper solutions depend on the individual "know-how" of the superintendent or on the keen judgment of the estimator.

The record seems to indicate that these obstacles either are real or that construction management firmly believes them to be real, since they have been little contested. A few companies employ "time studies," but these are usually confined to the cycles of large pieces of equipment. Historically, one of the founders of the science that developed into industrial engineering began in the construction field. Frank Gilbreth was a masonry contractor, and his improvements in bricklaying techniques, presented in the early 1900's, could bear review today by all of construction management. But Gilbreth soon turned to the more fruitful fields of shop manufacturing.

Obstacles become challenges, and the challenges are great ones when there is as much at stake as the level of productivity in the construction industry. Each of the four characteristics mentioned earlier, merits closer examination to determine how genuine and insurmountable an obstacle it presents.

A Custom Product.—This custom product is usually fabricated from common materials that have been used before by methods that have been used before. Although the overall structure may be unique, the individual cubic yards of earth excavated, buckets of concrete placed, or square feet of formwork built, erected, and stripped, are usually similar to thousands of other such units on the same job or on certain past jobs.

A Built-In-Place Product.—This condition presents a much greater challenge than that presented by industrial manufacturing. The industrial operator usually works at a fixed station under the same conditions for a long period of time. The construction worker moves continuously on the job and is affected by different working and climate conditions. Under these circumstances it is difficult to justify many of the possible improvements that would otherwise lead to more efficient methods. Jigs and specialized equipment, for example, lack mobility. Scientifically designed layouts of work locations may involve costs that could profitably be spread over several hundred cycles at one station but not over five or six cycles each at many locations.

It does not follow, however, that jigs, specialized equipment, and improvement of work layouts are ruled out. They must be developed with a knowledge of the variable working conditions and an understanding of the effects of each. Therefore a technique to analyze systematically and improve work methods or to develop estimating data should provide some means for taking into account and evaluating the many, variable work conditions.

A Non-Permanent Work Force.—There are two aspects of this condition. One involves the labor hired for the job which normally must come from the union local in whose jurisdiction the job is located. The second involves the supervisory personnel including foreman, craft superintendents, and sometimes the general superintendent.

The construction worker is a temporary employee not only because he must be hired locally but also because job activity, as well as overall company activity, continually fluctuates. It is difficult to justify special training for an individual employee who may be working for a competitor in another month. The easiest way out is to permit each man and foreman to go about his job as he sees fit, assuming that somewhere along the line he has acquired a know-

ledge of the economical ways of performing his type of work. Management, of course, decides the overall scheme of action and the choice of major equipment and methods, but details are usually left to the transient individual on the job. The result is that five foremen, given the same job to do, will probably perform it in five different ways. It would seem that one of these ways is better than the others; it also would seem likely that the best way of the five would fall short of a method devised in advance with careful planning.

The challenge for management to accept its full responsibility of determining the best methods of operation, including the details, is no different in construction than in other businesses except that it is more difficult to face. The non-permanent work force is one of the reasons for this difficulty. The contractor who makes no attempt to meet this challenge will not be able to compete with a contractor who can devise a successful method for meeting it. Such a method must provide a means for determining, down to the details, what is the best way to accomplish a given operation. But equally important is the requirement that this method must include a means to present and "sell" this work plan to the supervisory personnel who will have charge of its execution. This leads to the second aspect of the non-permanent work force obstacle.

Supervisory personnel are, at best, only semi-permanent members of the organization. Construction superintendents and foremen move frequently from job to job and from place to place. Tenure of employment is not as important to the individual as it is in most industrial situations. The contractor must deal with independent and individualistic men. Because management has largely relinquished control of methods and details to the immediate supervising foreman or craft superintendent, these men often, quite naturally, resent and resist those efforts by higher management to step back into the picture. The human relation problems in bringing about the adoption of improved methods are very possibly much greater than the technical problems of developing them.

While definite problems are created by the fluid work force in construction, it should not be overlooked that real opportunities also are created by this condition. New men with fresh ideas and critical views continually pass through the organization. These men may keep their ideas and pick up new ones from each company for which they work. On the other hand the alert company can pick up ideas and improved techniques from its men on all levels. When methods are detailed by management, criticism and suggestions should be encouraged. What is needed is a technique by which changes may be evaluated and the reasons for adopting one step rather than another justified by fact rather than by hunch or intuition.

Non-Repetitive Operations.—It is easy to point out many construction operations that are highly repetitive within the course of a single job. Trucks may haul loads of earth over the same route hour-after-hour, day-after-day, month-after-month on some excavation or embankment contracts. A cableway may run through the same cycle while placing thousands of buckets of concrete in a large dam.

But what is more important to appreciate is the broader concept that even for those operations that will not be repeated under the same conditions, there are repetitive components which are essentially the same on different jobs. While the overall cycle involved in a crane-and-bucket concrete-placing operation may never be exactly duplicated again after the placement is completed, the component parts of the operation may be very nearly duplicated on hundreds of concrete placing operations. The time it takes to land the bucket or to unhook from one bucket and hook on to a full one may be similar on operations

that otherwise appear very different. The time it takes to spot the bucket over the point of discharge, once it has been swung to that point, depends on several factors that might be isolated and taken into account. The time of actual discharge involves factors such as size and type of bucket, consistency of concrete, width of forms, and spacing of reinforcing steel. But these factors also could be conceivably isolated and considered.

What is needed, then, are analysis techniques that make it possible to study the effects of different job conditions on operation components. If these are understood, most operations may then be considered to be made up of repetitive parts. However, construction cost accounting does not offer such an analysis technique. Stop-watch time study is a possibility but a rather unsatisfactory one. Only limited detail can be recorded and the effects of some conditions may be overlooked or never appreciated.

Review.—The foregoing discussion of the obstacles to a methods-study type of approach to construction work indicates that the problems are not insurmountable. The characteristics of construction magnify certain difficulties beyond the proportions encountered in other industries. Techniques for methods analysis and improvement to be successfully used in construction must recognize the importance of these problems and provide a means for solving them. Summing up the requirements indicated, techniques are needed that:

1. Supply information about construction operations that can be converted to tangible working data on time and cost.
2. Provide very complete documentation of the operation in order that the many varying conditions under which work is performed may be taken into account in the analysis.
3. Provide effective means of presenting findings to supervisory personnel in a clear and understandable manner.
4. Permit an evaluation of changes in methods and provide a factual justification for methods adopted.
5. Permit maintenance of a convenient file of data on past operations that will provide complete documentation and permit study of component parts of operations when necessary.

Another characteristic of construction work that has a bearing on the success of an analysis technique is that most work involves crews of men engaged in interdependent activity. Frequently one or more machines also becomes an important part of crew operations. To properly analyze such work, data is needed on each man and each machine making up the team, and these must cover both individual and simultaneous activity. This information might be gained by employing a battery of industrial engineers, each armed with stop watch and pad, but such an approach is prohibitively expensive, impractical because of a lack of properly trained personnel, and psychologically unsatisfactory on a construction operation. Therefore another requirement for a successful analysis technique for construction operations may be stated as follows:

6. It must offer a practical means for following and providing data on the individual and simultaneous actions of a crew of men or of men and machines working together.

The writer has no knowledge of any techniques fulfilling these requirements that are widely used in the construction field. The closest approach in general use is the development of cost accounting data supplemented by job reports,

histories, and photographs. These fall far short of placing method improvement or cost estimating on a scientific basis.

AN ANALYSIS TECHNIQUE FOR CONSTRUCTION OPERATIONS

An analysis technique fulfilling all of the requirements proposed would be a useful tool for construction management. The method that will be discussed appears to have the desired characteristics. It consists of three phases common to most analysis techniques: data collection, data analysis, and effective presentation of findings. The data collection phase is accomplished by photographing construction operations with a movie camera. Instead of motion pictures at conventional speeds, however, individual exposures are taken at regularly timed intervals. The data-analysis phase is accomplished by studying the filmed operation with the aid of a projector which permits viewing the movie film one frame at a time. An essential accessory on this projector is a frame counter. Knowing the intervals between individual exposures, the frame counter permits the simple determination of elapsed time for any operation photographed. It is also essential that the film may be easily cranked backwards as well as forwards to make reviewing of the operation a simple matter. The presentation phase requires projecting and viewing the particular operations for which changes have been developed during the analysis stage.

Motion picture studies have long been used by industrial engineers. The Gilbreths proposed the use of micromotion studies as early as 1912. Micromotion study involves the analysis of movies usually filmed at normal, rapid camera speeds such as 1,000 frames per min (or 16 frames per sec). A more recent variation of micromotion study began to find industrial application in the late 1940's. It was developed by Marvin E. Mundel and is termed memomotion study. Its principal difference is that the motion pictures are taken at unusually slow speeds. Speeds of 100 frames per min are commonly used, but speeds as slow as 50 frames per min and 1 frame per sec are also frequently used. For both micromotion and memo-motion studies, the ideal equipment arrangement is a movie camera coupled to an external synchronous motor drive. This motor drive may have a gear shift arrangement permitting speeds ranging from 50 frames per min to 1,000 frames per min.

The data needed for analyzing many common construction operations can be obtained at speeds even slower than those normally included in memo-motion work. Most of the field work undertaken by the writer has been performed at speeds of 20 frames per min which allows a 3-sec interval between pictures. This gives a convenient and satisfactory unit for most operations equal to 0.05 min. There is nothing sacred about this interval, however, and there are undoubtedly operations that might be more successfully analyzed with either a shorter or longer time lapse. With intervals of this length or longer it is possible to trip the camera manually while watching a stop watch. The automatic operation using an external motor drive still has a number of advantages that will be discussed later. But manual operation permits less elaborate equipment, much greater mobility, and the elimination of the need for an AC or DC power source. All of these are matters of importance in developing a successful method adaptable for use on construction jobs.

The equipment and procedure for field work and for analysis and presentation will be described in detail after advantages and possible uses of the technique have been discussed.

ADVANTAGES OF ANALYSIS TECHNIQUE PROPOSED

The analysis technique discussed has many advantages, some of which are readily apparent. Before suggesting uses of the technique, these advantages will be examined.

1. The simultaneous activities of each member of a crew of men or of men and machines may be recorded precisely. The interdependent functions of each crew member may be studied by charting the activities of every man, one at a time, by re-examining the film as many times as is necessary.

2. One observer can record crew activities. Crew activities are the rule rather than the exception in construction work. To get as accurate working data for analysis purposes by stop-watch time study, almost as many observers as crew members would be required. This is normally impractical.

3. Neither the observer who operates the camera nor the analyst, who often would be the same person, needs to be highly skilled in industrial engineering to achieve worthwhile results. Recording the operation with the movie camera is much less difficult than making a stop-watch time study in the field. The techniques of analysis can be determined later in the office after viewing the operation several times. Development of useful data and operational improvements should be within the capabilities of the contractor's engineer and other personnel. However, this statement does not imply that specialized professional competence is not recommended or not more likely to achieve maximum benefits.

4. The technique is very economical as compared to other means of obtaining equivalent data. A single observer is required in the field. The necessary equipment represents a modest investment. And the film costs are very low because the pictures are taken at such a slow speed. With a 3-sec interval between exposures and 4,000 frames per 100 ft roll, one roll of film will cover $3\frac{1}{3}$ hr of continuous operation. With typical commercial discounts the total costs for film and processing to cover this time of continuous operation might be between $7 and $8 for black and white and between $11 and $12 for color, using 16 mm film.

5. A tremendous wealth of detail is available on the hundreds of pictures taken that will serve to record the many conditions under which the work was performed. An observer may make notes, draw sketches, and even take photographs (these steps are also recommended with the proposed technique), but it is not possible by these methods to record as much information affecting the operation as by continuous filming. As indicated earlier, a real obstacle to the systematic improvement of construction operations or the collection of useful data for estimating and planning is that operations seldom continue or are repeated under the same set of conditions. It appears that the best solution is to record and evaluate the effect of each condition.

There is a second important aspect to the advantage of the wealth of detail recorded in filming. It is not always possible to foresee what conditions are important to record for later analysis of an operation. With the movie technique, future studies are possible that involve breakdowns of an operation into different components or that analyze the effects of conditions not originally recognized. This is not possible with stop-watch time study.

6. Analysis of film can be made at any later date. The wealth of detail recorded will still be preserved. Perhaps immediate analysis may be undertaken

for the purpose of method improvement on a current job. But when slack time permits or future jobs with similar operations come up, further analysis and new information can be obtained from films taken earlier.

7. Films may be easily indexed and filed for future use. Similar operations from different jobs may be spliced together for filing purposes.

8. A graphic, easily understandable presentation of operations analysis and improvements is possible. The method permits findings and recommended changes to be passed on to job supervisory personnel in a manner that is much more likely to be successful than mere figures and charts. It is not only a more understandable presentation but one that is fair to job supervision and not likely to result in changes that are not really justified. This is true because job supervision may be given the opportunity to review the operation and defend it or explain conditions not known to the observer or analyst.

9. Evidence is preserved showing the original methods by which an operation was performed. Analysis may result in improvements of this operation over a period of time. Moreover, each step may represent a simple and obvious change when viewed in retrospect. It is easy to forget the original methods and to fail to appreciate the value of improvements. A comparison of the original operation, recorded on film, with the final operation makes possible an evaluation of savings. These may be compared to the costs of applying the technique to help determine if the returns justify its continued use.

10. The film obtained in using this technique provides excellent material for instruction and development of personnel. The evolution of profitable changes can be illustrated to company members on all levels to create a frame of mind conducive to further improvements. Group viewing of past operations may encourage suggestions and discussion of problems. Methods developed on one job may be passed on to other jobs.

These ten advantages warrant consideration of the method as a useful analysis tool with particular applicability to construction operations. All requirements for an effective technique that were developed in our early discussion are fulfilled.

SUGGESTED APPLICATIONS OF PROPOSED TECHNIQUE

The film record obtained by the proposed technique is one well documented in detail, accurate, and showing the simultaneous actions of all crew members. A number of formal methods have been developed in industrial engineering practice to analyze operations where such data has been obtained. These methods include the construction of process charts and multiple-activity charts, both of which have numerous variations. Simply stated, the process chart is a condensed representation of the type and sequence of all steps involved in a particular job. The multiple-activity chart is a graphic representation of the simultaneous activities of a crew of men or of men and machines. Once constructed, the steps and activities shown on these charts are questioned in accordance with well-developed check lists. This approach leads to systematic improvements and seems to promise the most extensive benefits.

It is felt that the trial and adoption of the movie study technique in the construction industry will be much more likely if worthwhile results can be obtained with a minimum of specialized training by personnel already employed. This is probably even more true in the case of the analysis stage than of the field work required to produce the film. A contractor that might not hesitate

to hire a professional photographer to take pictures might be quite reluctant to hire specialized engineering talent to develop better methods for performing his work. Actually neither outsider seems necessary. Every construction firm should have personnel qualified to do the field work and also able to produce worthwhile results in the analysis and application phases. Once some success has been achieved, management would have less reluctance to seek specialized skills. However, this would probably not be necessary because the personnel who made the original efforts will study and attempt applications of more refined and formalized methods. The next logical step is to develop new analysis techniques particularly suited to the characteristics of the industry.

In this paper no attempt is made to present formalized methods, either existing or proposed. Five possible fields of application for the movie analysis technique are offered and general approaches are suggested.

Methods Improvement.—Constant improvement of methods is essential in a competitive industry. Some of these changes come in dramatic fashion after sudden inspirations. But consistently improved performance depends on frequent modifications, both big and small, and these result from careful study of existing operations. Such study on construction work is often based on direct observation, supplemented by a good knowledge of costs. For important problems, stop-watch time study data is sometimes collected.

The film analysis technique offers another basis for careful study. Among its advantages that are important for this application are:

1. Viewing an operation under conditions favorable to calm and constructive criticism.
2. Re-viewing of an operation as many times as desired and as slowly or fast as desired.
3. Pictures of the operation that give almost complete details of the conditions under which it was performed.
4. The possibility of breaking the operation into component parts and obtaining accurate time data even where the cycle is irregular and the observer unskilled in time study methods.

Having obtained a film showing a complete cycle or several cycles of an operation, the operation may be broken down into a number of component parts. This may be accomplished by cranking the film back and forth until definite break points are noted and agreed upon. A corresponding frame-counter reading at each such point permits simple determination of the time required to perform each operational component. The pictures themselves, supplemented by field documentation, provide a record of personnel and equipment taking part in the work. Knowing labor and equipment costs, the cost of each operational component may be calculated. The recorded data also provide a record of delays and causes. Once costs are determined for each operational component and delay, primary attention can be focused on the most important aspects of the problem.

It is advisable to examine the overall operation before studying individual parts in detail. The steps may be listed in the sequence in which they occur. Then the necessity of performing the entire operation and each of its component parts, as well as the order of performance, may be first questioned. There is no sense in making a detailed study of the method used in a step that might be eliminated or that should be performed at a different point in the sequence with certain necessary changes.

The most logical target for a methods' improvement study is a highly repetitive operation that is just getting started. Such operations should receive careful and early attention. The effect of any improvement that is made will be multiplied many times and the sooner made, the more times multiplied. Changes can be justified cost wise for a highly repetitive operation that cannot pay their way in fewer cycles.

Important opportunities for profitable methods improvement of a broader nature are offered by less repetitive operations also. It may not be possible to apply the improved method on the same job that indicated its desirability. But its application on future jobs may make valuable contributions to a company's long-range success.

One possible type of improvement illustrating the latter point is a change in design practice over which the contractor has control. For example, certain films of form erection indicated delays and difficulty in the field assembly of shop-built form panels. Unforeseeable variations in field conditions prevented precise fits and necessitated hand sawing and other modifications causing long delays. An alert superintendent would relay such problems back to the form designer. However, the movie analysis provided much better information for evaluating how serious these delays were and how much might profitably be spent to cure them on future work. The film indicated not only the direct delays but the adverse effect on other related cyclic operations. When similar work was encountered again, the designer might devise a new scheme permitting a simple and rapid means of modification during field assembly. A second example, somewhat similar, resulted from an analysis of the removal of individual pieces of form hardware as shown on films of a form stripping operation. Several pieces required unusually long times. Re-examination of the film indicated that the scaffolding was poorly located with respect to the hardward in question. This scaffolding was built integrally onto the form panel. This defect had gone undetected. Once brought home to the designer, more care could be given to future detailing of scaffolding.

A second type of improvement of a rather broad nature might be illustrated by a study of operational delays. Almost every operation involves several delays that account for a substantial amount of time. The specific delay, however, may not occur again. Many of these can be traced to a failure to have the right tool at the right time or to the lack of instructions as to what to do next. A related source of lost time is the rehandling of materials or the repetition of work because there has been no advance planning. A remedy for this general category of delays is the preparation of a simple pre-plan for each operation. This would indicate what is to be done; the labor, equipment and tools required to do it; and an outline of how it is to be accomplished. Films of operations could not only provide justification for such a policy but could indicate the effectiveness with which it was being carried out. This would probably be a by-product of other studies.

In seeking improved methods, the film analysis technique permits examination of the abnormal cycle as well as timing the average cycle. Where an operation is filmed over numerous cycles, the times can be listed. Usually the average cycle receives the most attention. However, the records of the unusually slow and the unusually fast cycles often have important information to offer. Scanning the tabulated cycle times, these abnormal cycles can be located, observed again, and carefully studied. The conditions responsible for the very long cycle may be discovered and possibly avoided in the future. More

important, it may be possible to duplicate the conditions resulting in the very short cycles and to adopt this procedure in the future. The type of information needed for such studies is generally lost in other analysis techniques.

Trouble-Shooting.—Responsible contractors establish cost accounting systems for each job, breaking the job into a number of activities and indicating a budgeted amount of money for each. When actual field costs differ substantially from budgeted costs, there is an indication that something is wrong. It may be that field work is being poorly executed or that field methods do not follow the plan envisioned by the estimator. Or it may be that the estimator based his figures on an unrealistic method or was overly optimistic about production. The cost accounting system can indicate that a problem exists and can show the area in which it exists. But no matter how detailed the system is, it usually does not pin point either the trouble or the responsibility for the trouble.

Assuming that the cost item involved is an important one and that management is aware of the problem early, or that the same type of operation will occur on future jobs, it is very desirable to determine the cause of the discrepancy between budgeted and actual costs. By filming and analyzing one or more complete cycles of the operation, the cost accounting figure can be verified or challenged and trouble-spots may be isolated. Careful study by both job supervision and the estimator should result in constructive criticism. Both will desire to justify their part in the work, and each can make contributions to help the other when given such an opportunity.

A further advantage in connection with trouble-shooting applications is that a full cycle of a long operation can be recorded on the job and brought into the home office for study. The erecting, stripping, and repair of forms for a repetitive concrete placement may represent a cycle of 3 or 4 days. Top management and estimating personnel seldom can devote that amount of continuous time to field observations on one project. But when studies are made by other methods and sent back to the home office, there usually is insufficient detail to explain completely how and under what conditions the operation is being performed. The film analysis technique overcomes these difficulties.

Presentation and Education.—Finding a method improvement or operation shortcoming is only part of the job of accomplishing a cost reduction. The improvement must be put into effect or the shortcoming eliminated. In either case, a "selling" job is required. Many worthwhile improvements that might result from formal and detailed studies by highly paid outside consultants mean only an unjustified expense if job supervision cannot be convinced of their value. Suggestions, even when supported by figures and charts, are often more easily sold to home office management than to the man actually in charge of performing the work. Yet it is the support of the latter that is essential.

A film of past work permits a clear and understandable demonstration to supervision of the conditions that led to a suggested change. As pointed out before, it also gives the field man an opportunity to explain and defend existing methods. Otherwise, in some cases, changes may be forced upon him to the detriment of job costs as well as job morale.

The critical viewing of films of their company's operations provides an excellent means for making personnel conscious of method improvement opportunities and of the advantages of good planning and organization. To drive home a point, an operation may be viewed with the same time interval between frames as was used in the filming. Watching a crew of men standing idle during the

span of an unnecessary delay is much more effective than a mere presentation of written facts and figures.

For the education of engineers and foremen, the study of films showing various methods and the development of time and cost data from them can be a very valuable by-product of the movie analysis technique.

Estimating Data.—The common procedure in estimating new work is to draw on past experience where it is available. This past experience, at best, is recorded in the cost data obtained from jobs having similar operations. However, the cost data has very limited direct application, even after adjustment for changes in price and wage levels. It has been pointed out that in construction work similar types of operation are normally performed under very different conditions on each job. The cost data must be modified by a judgment factor to give a quantitative determination of how much more or less difficult the operation at hand is as compared to that on the past job. Such adjustments might be made on a sounder basis if films were on file to show the conditions under which the historical operation was performed. This would assume that the operation is important enough in the future job to warrant the time spent in viewing such films.

Considering this procedure with a much broader viewpoint, the possibility should be studied of developing estimating data that minimizes the degree of individual judgment required for its use. When the application of electronic computers, capable of performing tedious calculations and drawing information from storage sources, is suggested for construction estimating, the necessity of this great degree of individual judgment is cited. It is suggested that a long range program based on analysis of data obtained by the movie technique could put estimating on a more scientific basis and even, possibly, permit computer applications.

A competent industrial engineer can predict with reasonable accuracy how long it will take a person to perform a given task. For example, how long will it take for a man to stand up, walk across the room, pick up a book, and return to his chair? There have been developed tables giving the number of time units required for certain elemental movements. For these, almost any conceivable sequence of movements can be assembled to represent an operation by combining the times required for such motions as Stand, Walk (per pace), Reach, Grasp, Turn Body, etc. While the application of these detailed elemental times may not be immediately practical for construction estimating, a parallel system involving the times required for recurring elemental parts of repetitive operations may have value.

Consider the case, mentioned earlier, of the concrete placing operation with bucket and crane. This basic operation is repeated thousands of times by individual contractors, but every placement varies in some respects. The overall operation might be broken down into a number of component parts, and the conditions affecting the time for these component parts might be studied. With such information, the construction estimator might be able to assemble an artificial operation in the fashion that the industrial engineer predicts the time for a series of movements.

To carry the illustration further, assume the concrete placing operation is broken down as follows:

A. Unhook from empty and hook on full bucket
B. Hoist and swing bucket to dump location
C. Grasp and spot bucket ready to dump

D. Dump bucket
E. Swing and lower bucket to fill location
F. Spot and land bucket

The time to perform each component is affected by a number of conditions. By analyzing numerous film records, all showing in detail the conditions that existed for any single placement, these components can be studied and the effect of various conditions isolated. For example, the time to "hoist and swing bucket to dump location" might depend on a number of conditions such as:

1. Height of hoisting
2. Angle or distance of swing
3. Necessity to boom out or back
4. Visibility of dump location or reliance on signalman
5. Size of bucket
6. Size and type of crane
7. Skill of operator

Some of these conditions may have considerable importance and others have little effect. It appears that the task of evaluating each of several components for each of several conditions will be a great one. If more dependable estimating for a highly repetitive type of work resulted, the effort could be justified. Moreover, it is probable that findings leading to better methods would be developed long before data collection was finished. The concrete-placing operation has been cited merely to illustrate the approach; setting and stripping framework, for example, may be a more fruitful area of study. Whatever the subject, the method of approach is generally the same.

The need for keen estimating judgment would not be eliminated even if an artificial operation could be developed with considerable accuracy. However, the application of judgment would be confined mainly to the necessary allowance for delay time, both avoidable and unavoidable. This delay time is of considerable importance in most cycles, amounting to perhaps 25% to 50% of the total time. The fact that its effect is isolated is very worthwhile, since once its importance is fully felt, efforts to minimize the delay portion of operation cycles will be more pronounced. In addition, by isolating such non-productive time, a measure of job supervisory efficiency might be established.

Methods and Equipment Selection.—Method and equipment selection, to be intelligent and correct, must be based on facts. All too often they are not available, and the adopted plan is based on intuition or on the familiarity of the job superintendent with one of the alternatives. For example, even on the same job, superintendents and foremen will argue the merits of one type of form hardware versus another. The comparative material costs are relatively simple to determine, but comparative labor costs are often matters of opinion. Reliable data on the time to install a single tie or to remove it, the time to make necessary adjustments, and the time to patch the different size holes left in the concrete, is lacking.

Conventional sources of data often do not give results in sufficient detail to serve as a dependable guide. Cost accounting data may indicate a lower unit price on past jobs for one method than another. However, many cost components are generally lumped in any cost accounting item, and these components may be in different proportions on different jobs even though the work appears similar. In such cases, this apparent factual basis for method selection may be completely misleading.

The data needed to develop accurate times for estimating purposes will also serve as a basis for method and equipment selection. Once a job has been successfully obtained, method and equipment studies should be repeated in greater detail. If a set of data has been developed by the movie analysis technique, its application in job planning should be even more productive than in estimating, since more detailed study is justified.

Data for both estimating and planning can be continually improved as time goes on. Experiments can be undertaken with different size crews, with different capacities of equipment, and with variations in equipment types and accessories. Where these experiments do not lead to immediate method improvements, they will at least produce data that may aid future choices.

DETAILED DESCRIPTION OF EQUIPMENT AND METHODS

Camera and Tripod.—A good movie camera capable of producing a clear picture is a prime requirement. The 16 mm film gives the analyst more detail with which to work than does 8 mm film.

A three-lens turret is desirable. A regular lens, a wide-angle lens, and a telephoto lens may all be used to advanta , sometimes while film.ng a single operation. For example, the wide-angle lens will permit pictures showing the entire scene of the operation including the relative position of equipment and material sources. The regular lens will permit concentration on the movements of a crew engaged in the principal activity in progress. The telephoto lens will permit sequences to be filmed of the detailed motions of one of the crew members. If the turret is equipped with a handle, quick changes can be made from one lens to another without missing any exposures and without disrupting lens settings. This requires a view-finder that may also be changed quickly to correspond to the focal length of lens being used. A vari-focal (or zoom) lens was not tried. Such a lens has a variable focal length that permits any angle of view within a certain range. The range may be nearly as great as that from a wide-angle to a telephoto lens. This would be an advantage because the maximum degree of detail could be obtained by adjusting the lens to just cover the required area of activity.

A full winding of the spring motor drive in the camera, used by the author, permitted the taking of over 700 pictures. At a 3-sec interval this is equivalent to more than a $\frac{1}{2}$ hr operation. There is no necessity to interrupt filming even at the end of this period since the camera may be rewound a turn or so at a time between exposures.

Pictures may be taken over a period of several hours while following work at a single location. Therefore the camera should be tripod mounted. It should be possible to rotate easily the tripod head in both horizontal and vertical directions and to clamp it quickly in any position. Telescoping legs are desirable. They may be easily adjusted for difficult camera locations. Moreover, compact equipment is important when position changes involve ladder climbing and movements through restricted openings. Sharp, pointed tripod feet have been found advantageous in setting up on narrow scaffolding planks and other confined footings.

Timing Devices.—If the interval between pictures is long enough, the camera can be tripped manually. In this case a stop watch hung from or near the camera is the simplest timing device. A conscientious operator is capable of

achieving satisfactory results with manual operation. While any one interval between exposures may be incorrect by perhaps as much as 50%, there should be no cumulative error. The time derived from a large number of frames should be closer than a single interval to the corresponding total time measured by the stop watch. No greater accuracy is warranted.

The principal disadvantage of manual operation is that the operator must stay at the camera and has no time for other activity. It should be readily apparent that detailed documentation during filming is very important for later analysis. Even though the pictures will show the scene of operations in full detail, many questions need to be answered. For example, what is causing a delay or where is a man going who leaves the work location or what is taking place on the far side of a vertical form panel, etc? To obtain answers to these questions for the analyst, the camera operator should be able to leave the camera and should also have the time to record his findings. Obviously, a single operator cannot do these things while tripping the camera shutter every few seconds.

One solution to this problem is a second operator, but this doubles the labor requirement for obtaining data. A second solution is an automatic drive. Such automatic devices are standard for micromotion study. They consist of an external, alternating-current motor, with a gear box, that drives the camera at a selected speed. This equipment is mounted beside the camera on a base plate which, in turn, is mounted on the tripod head. Available standard equipment could probably be further geared down to the slower speeds that seem desirable for construction studies and could be converted for battery operation. Another alternative would be the design and construction of special equipment. While this custom equipment could also be designed to drive the camera directly, making periodic rewinding unnecessary, a simpler arrangement might be achieved with a timer and solenoid employed merely to trip the shutter as in manual operation. Direct current power sources or spring motor drives introduce problems of timing accuracy that must be considered. If a battery is chosen as a power source, it should be of such capacity that a single charging would provide ample power for a whole day's filming.

In deciding between manual and automatic operation the disadvantages of decreased mobility must be weighed against the advantages of better documentation. There are situations where either type of operation may be preferable to the other. Therefore, it is recommended that the operator have equipment for both manual and automatic operation.

Other Field Equipment.—An exposure meter, properly used, is recommended, since correct exposure is necessary to give clearly defined detail on the film. A note pad is essential. Information about the operation must be recorded and elapsed time for interruptions in picture taking must be logged. A well-designed bag or carrying case for camera, accessories, film, and tools will provide protection for equipment.

A major piece of equipment which has not been tried but is suggested as a possibility is a tape-recorded type dictaphone. These units are available in very small sizes including their battery power source. If manual operation were being used, the dictaphone would permit the operator to record remarks on the tape and reference them to stop-watch times or to frame counter readings. This could be done while pictures were being taken. Even with automatic operation, the dictaphone might offer an advantage. It would encourage more complete documentation since it is easier to record observations orally and one can continue to watch them while recording. Here again the question of mobility must be balanced against the advantages of this type of equipment.

Field Operation.—Common sense and planning are required to obtain good pictures. The operation to be followed should be reviewed in advance to estimate how long it will take, over what area it will take place, and where most of the action will occur in any one location. Suitable camera positions are often extremely difficult to find and should be chosen in advance if possible. It is desirable to be as close to the operation as possible in order to record detail but, at the same time, to be far enough away that the entire work scene and all members of the crew can be included by using the wide-angle lens. Lighting is very important and changes during the course of the day should be anticipated. To avoid interruptions, camera positions should not be in the paths of equipment or workers. Sometimes an operation will require a choice as to what portion will be filmed. When a large vertical form panel is being set, pictures can be taken on one side or the other but not both, unless two cameras are employed.

Any delays in picture taking may be indicated on the film by covering the lens to produce one or more blank frames. If the camera is stopped during the delay, then the starting time of the delay and the time picture taking is resumed should both be logged in the notes.

Valuable information can be recorded during an operation by occasional side shots. For example, the time at which the next ready-mix truck arrives at the site, or the destination of the crew member who leaves the scene to get more nails or a different tool, can be shown. These facts may help the analyst in suggesting operation improvements. Before and after an operation has been filmed, a series of miscellaneous shots may be taken to show the area surrounding the work location and to note special details that affect the operation. These will supplement the notes and sketches prepared by the person conducting the study.

Periods ranging from 4 days to 2 weeks were spent on different projects experimenting with the field operations for this analysis technique. During that time there was no indication of objections or hostility by the men on the job or their union representatives. There was interest in the procedure and its purpose, and questions were answered as fully and clearly as possible. Most operations were filmed over continuous periods of $\frac{1}{2}$ hr to one-half shift. The writer was unable to detect any change in the level of activity when picture taking was commenced or completed.

Film and Processing.—For micromotion studies of shop manufacturing operations, black and white film is used almost exclusively. Its higher speed is desirable for indoor work, and it is more economical. Most construction work is outdoors, and the slower color film can be used. Proper exposure is more critical. Under some conditions this can be a decided disadvantage. For example, in photographing a pipe laying operation in a deep trench, series of pictures were taken alternately of trench-bottom activities and trench-side activities. The frequent changes in camera setting required by color film were avoided by use of black and white film. The pictures taken into the trench were somewhat underexposed, and the other pictures were somewhat overexposed, but all were useable. Cost of film and processing is about 50% higher for color. Where the color is an aid to the analyst this extra expense can generally be justified. When the work is some distance from the camera and a large number of men are in the crew while others, including inspectors and engineers, appear for intervals, color helps to distinguish one individual from another.

Film selection also depends on availability and processing service. Many camera stores do not stock black and white film because of the small demand

for it. Therefore it should be purchased in sufficient quantity before leaving for the job site. In some locations processing service is faster for black and white film and in other locations it is faster for color film. Service may range from less than 1-day's time to 1 or 2 weeks or more. Where job-site analysis is planned with the objective of immediate method modifications, processing time is very important. It is conceivable that a mobile processing kit would be a necessary item of equipment.

Film Analysis Equipment.—Individual frames on films may be viewed at length. Therefore the projector used for analysis purposes must be equipped with a low wattage bulb or an effective blower or generally both. The film is turned slowly and frequently stopped, and this may be done simply by a hand crank. It is essential that this cranking be done easily in both directions. A frame counter is a necessary accessory on the projector as it gives the length of each operation and also serves as an index for rapidly finding a given point on the film. The film may be projected on a small shadow box screen set on a table top on which the analyst works. Standard printed forms will assist in indexing the contents of various films, in documenting and logging any delays on each film, and in performing analysis studies.

CONCLUSION

This paper has suggested the use of an analysis technique for construction operations and has indicated its advantages, proposed several types of applications, and described in some detail the equipment and procedure. The writer feels that in many situations this method will furnish more useful data than other possible analysis methods and will overcome certain obstacles to the successful improvement of construction operations.

Such improvements can be attained through changes in performance that are completely within the domain of management. When formal approaches to methods' study are suggested, the remark that "the unions won't let us" is too common. In most cases this is an excuse rather than a valid reason.

The writer's experience, admittedly limited, has been that the average worker on an engineering construction project is willing to perform a reasonable day's work. His output could be increased markedly, but chiefly by planning his work in advance and giving him better instructions, by seeing that he has the right tools at the right time, by not requiring him to perform unnecessary operations, by making him part of a correctly sized crew, and by not slowing him down as a result of avoidable delays. All of these should be management functions.

Our nation's Number 1 industry deserves more attention directed towards increasing the level of production. The analysis method suggested here is supported by only limited field application on construction projects. It may provide a useful tool. It is hoped that it will receive further trial in construction and that better defined procedures for field work and film analysis, adapted to construction, will be developed.

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CONCRETE ADDITION TO CELLULAR SHEET PILE SHIPWAY

By John W. Irvine,[1] M. ASCE and Richard F. Gaston[2]

SYNOPSIS

A graving dock used as a shipway, and constructed of cellular sheet piling in the early days of World War II, has been lengthened 100 ft. The additional length was provided by sinking a reinforced concrete trapezoidal-shaped cofferdam with the aid of open dredged wells.

The opportunity for construction of the first nuclear powered aircraft carrier necessitated lengthening of submerged Shipway No. 11 at the Newport News Shipbuilding and Dry Dock Co., Newport News, Va.

In 1940-1943, in order to provide for the construction of major naval vessels (particularly aircraft carriers) the Newport News Shipbuilding and Dry Dock Co. constructed two adjoining shipways, the larger of which was Shipway No. 11 (1,000 ft long, 140 ft wide at the gate entrance, and 40 ft deep over the sill at mean high water). In this shipway there were constructed six LSTs which were launched simultaneously, and since that time, many aircraft carriers of the ESSEX Class, the MIDWAY Class, and later the FORRESTAL and RANGER.[3]

Note.—Discussion open until October 1, 1960. Separate Discussions should be submitted for the individual papers in this symposium. To extend the closing date one month, a written request must be filed with the Executive Secretary, ASCE. This paper is part of the copyrighted Journal of the Construction Division, Proceedings of the American Society of Civil Engineers, Vol. 86, No. CO 2, May, 1960.

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[3] Transactions, by M. M. FitzHugh, J. S. Miller and K. Terzaghi, Vol. 112, 1947, p. 298.

The first nuclear powered aircraft carrier which is to be christened the ENTERPRISE, after its famous predecessor, which was also built at Newport News, was designed with its length greater than the 1,000 ft capacity of the shipway.

It was necessary, therefore, to lengthen the shipway and designs were made and plans drawn to increase the original effective length to 1,100 ft. Several methods of adding this additional length were investigated. Although the natural inclination was to continue the extension in cellular steel pile construction, there was the difficult problem of maintaining not only the stability of the present structure which depended on the interlocking cells, but also the adjacent shop buildings and equipment. It was, therefore, decided to adopt a plan using a concrete caisson.

Design plans and cost estimates were invited from the original builders of the shipway, in 1940, due to their familiarity with the site and ground conditions and after acceptance, work was commenced on April 28, 1958.

Prior to the contractor starting work, it was necessary to relocate all underground facilities in the area. This involved moving a sanitary sewer, storm sewer, 10 KVA cables, oxygen and propane gas lines, air, steam, fresh and salt water lines. The contractor only had to remove one foundation footing from an abandoned trestle, the roadway paving and the concrete wall and walkway across the head of the shipway.

When the caisson was first laid out, it was found that an existing 36-in. diameter deep-well, installed when the shipways were built, was out of plumb and would foul the cutting edge of the caisson before it reached plan grade. Therefore, the north-south axis of the caisson was moved 16 in. toward the east.

The caisson was unusual in some respects, as it was open on one side which had to be closed with a temporary timber bulkhead. It was 94 ft by 76 ft in area and 61 ft deep, from the cutting edge to the top of the capped wells. The site of the extension showing partial excavation preparatory to setting the steel cutting-edge is shown in Fig. 1.

The cutting edge, along the entire outside perimeter and along the longitudinal center line, consisted of two $\frac{1}{2}$ in. steel plates 18 in. wide, one vertical and the other inclined at a 45° angle, welded continuously and reinforced with 1-in. diameter reinforcing rods 4 ft long, with hooked ends, spaced at 12 in. center to center (Fig. 2). This cutting edge was fabricated by the Shipyard for the contractor.

The entire perimeter and the longitudinal center line was excavated to a depth of 6 ft and the cutting edge was set at El. 103.

While preparations were being made to set the cutting edge, the straight wall forms and the barrel forms (for the dredging wells) were being built in the bottom of Shipway No. 11. These forms were built 16 ft in height to handle the maximum concrete pour contemplated.

After placing the cutting edge, next came the first setting of the barrel forms. These were set with their bottoms at the original ground level, which was decked with scrap boards. This would be the top of the work chamber of the caisson. All excavation would be from this work chamber through the dredging wells (Fig. 3). Following the setting of the barrel forms the outside forms were set to enclose the first concrete pour which was 1,050 cu yd. This form-setting procedure was repeated four times, with two concrete pours being made before each shifting of forms. The total concrete in these eight pours was 6,760 cu yd.

FIG. 1.—SITE OF SHIPWAY NO. 11

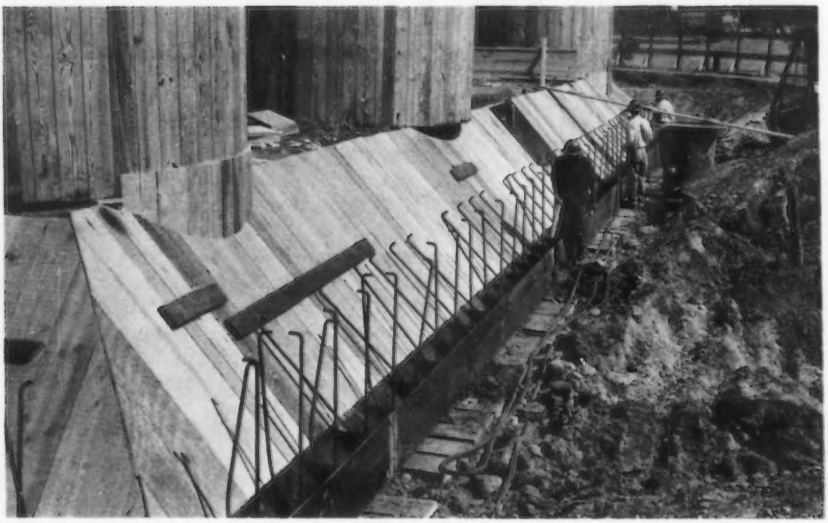

FIG. 2.—STEEL CUTTING EDGE

All concrete was transit-mixed and was transferred in place with six 2 cu yd bottom-dump buckets, handled by two whirler derricks, one each side of the shipway, track mounted for mobility. This set up and procedure worked satisfactorily and all succeeding pours were handled in this manner. Fig. 4 shows the initial slab completely formed ready for pouring, and Fig. 5 with the forms removed. Excavation has just begun in this photograph and cranes can be seen dropping earth into hoppers and awaiting trucks.

After pouring the first section of the caisson, and proper curing, excavation started, working through the dredge wells with $1\frac{1}{2}$ yd heavy duty clam-shell buckets. When the wells were excavated to the approximate depth of the cutting edge, the areas between the wells then had to be broken out by hand excavation. The first 10 ft of excavation was hauled-in fill and was relatively easy

FIG. 3.—INITIAL SLAB WITH STEEL CUTTING EDGE

to dig; however, below this level, blue marl was encountered. This is a sandy clay with some shells, and in the undisturbed state it is very hard. Hand picks, air spades, and water jets were all used to loosen this material but progress was so slow some other method had to be used. The contractor, with the Yard's permission, then resorted to the use of dynamite. A total of 6,545 sticks of 20% dynamite was used. In Fig. 6, the caisson has begun to take its completed shape. The first section has been added to the initial slab.

With the removal of the excavation under the caisson its sinking was accomplished by its dead weight. As each additional lift of approximately 16 ft was added the sinking became more uniform. Also, it involved the problem, where the marl was dry on the east side and wet on the west, of holding the caisson in a level plane. To check this feature, four caisson levelling gages—rubber hoses filled with water—with sight glasses at the four corners, were used. To control the level movement of the caisson the excavation was altered

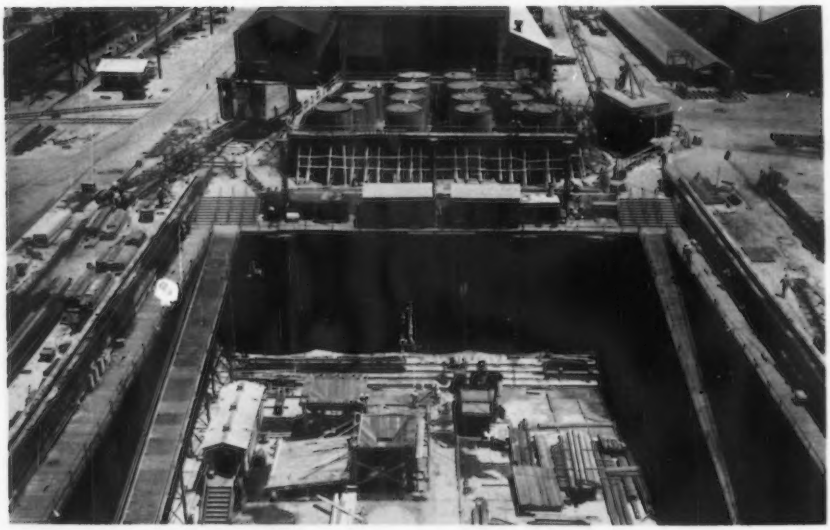

FIG. 4.—INITIAL SLAB READY FOR POURING

FIG. 5.—INITIAL SLAB WITH FORMS REMOVED

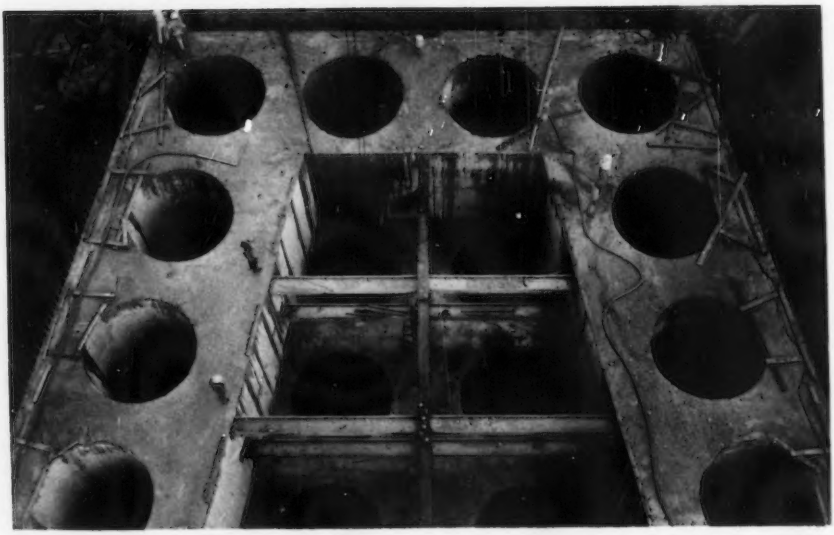

FIG. 6.—CAISSON TAKING SHAPE

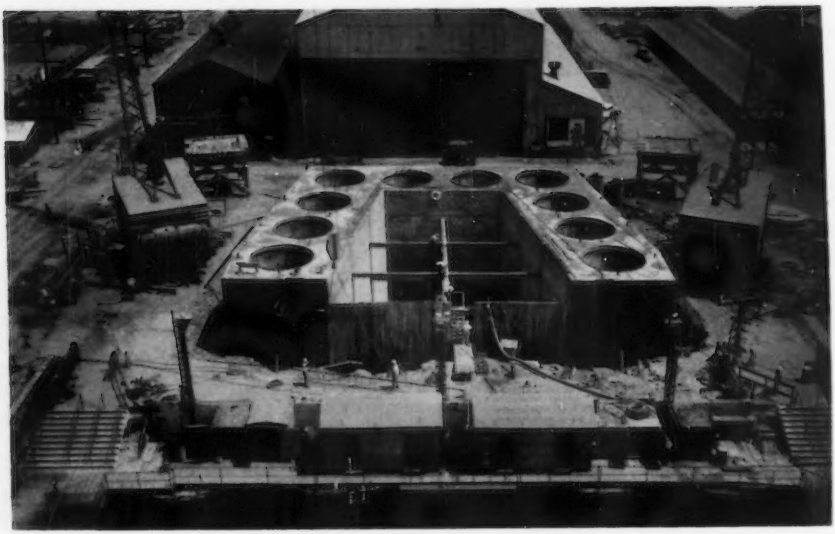

FIG. 7.—INTERIOR BRACING CONTINUES AS CAISSON GOES DOWN

from side to side and end to end with interior bracing inside, as shown in Fig. 7.

After making four 15-ft lift pours, of approximately 6,760 cu yd, preparations were made to clean out the work chamber and pour the seal. At this point a prolonged rainy spell set in. The caisson cutting edge having reached the plan grade at El. 40, began to settle more. This condition was caused by the excess rain and the fact that at about El. 40 the marl ran out and a layer of fine silty sand was encountered. To stop further settlement, the caisson was flooded and preparations made to use a high-pressure jet for cleaning out the work chamber under water.

After the work chamber was cleaned out, it was divided into four sections by the use of bagged gravel dams. One section at a time was poured by the tremie method. The pours were altered from corner to corner to maintain a level plane. A total of 1,395 cu yd of concrete was poured in the entire seal, making a total of 8,155 cu yd of concrete in the complete caisson.

With the caisson sealed at the bottom, the dredge wells around the outside were capped and sealed (Fig. 8). Work then started on the retaining walls on the top inside edge of the caisson.

The excavation of cells 81 and 85 followed, on each side of the planned opening in the end shipway wall. As these two cells were excavated, steel bracing was placed to prevent them from being disturbed or displaced. These two cells were excavated to El. 52, two of the 13 ft diameter well forms placed and the entire cell outside of the wells was filled with concrete (Fig. 9). The original plans called for wood piles in the bottom of these cells, however, after examination of the bottom it was decided they would not be necessary. During the process of placing the bracing in cells 81 and 85, the excavation of cells 82, 83, and 84 was commenced.

While the excavation of cells 82, 83, and 84 was in progress, steel sheet-pile closure walls were driven on each side between the caisson and the back of cells 81 and 85. This served as a back form and left in place for the closure concrete walls.

As the excavation of the three cells that were to be removed, progressed, the temporary timber bulkhead on the open end of the caisson was removed. Then the removal of the steel sheet pile began. It was necessary to remove these piles by splitting about every fifth or sixth sheet, burning them off at the bottom and lifting out in a group. Pulling individually was too time consuming and in some cases impossible.

Next, 188 wood piles, 36 ft long, a total of 6,280 lin ft were driven in the bottom of cells 82, 83, and 84, as shown in Fig. 10. The floor section was formed and poured in six sections, three on the caisson and three on cells 82, 83, and 84, fairing in the last pour with the existing shipway floor. Along with the pouring of the floor the closure wall between the caisson and cells 81 and 85 were brought up to El. 98. The retaining wall at the top was extended from the west edge of the caisson across the closure area and across the tops of cells 81 and 85 and returned to the side of the stairway leading to Shipway No. 11 (Fig. 11).

Of special interest is a portable bridge 22 ft wide across the end of the extension, as shown in Fig. 11. This bridge will enable traffic to continue to flow without having to cross the mainline railroad track which brushes the end of the extension. The bridge was fabricated in the bottom of the Shipway and set on seats previously cast in the top of the retaining walls. Forming and pouring this bridge completed all concrete work on the project.

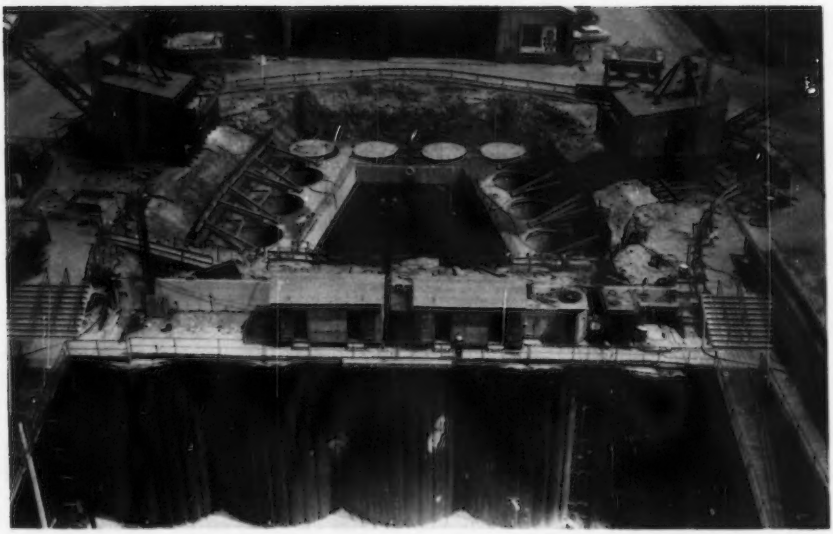

FIG. 8.—CAISSON AT FINAL ELEVATION

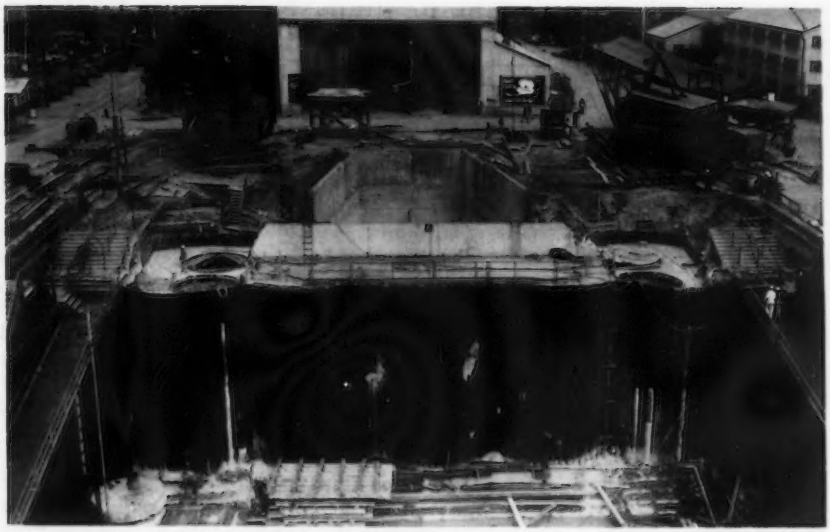

FIG. 9.—RETAINING WALL ADDED

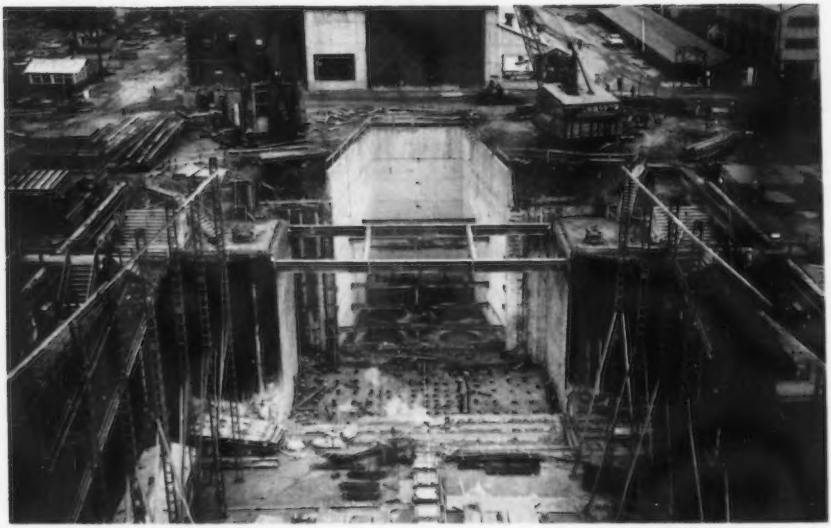

FIG. 10.—THREE CENTER CELLS REMOVED

FIG. 11.—EXTENSION COMPLETED

The remaining work consisted of backfill, separating steel sheet pile, placing handrail, and dismantling and loading out equipment.

A total of 12,936.5 cu yd of concrete was used and it took the contractor 264 days of operation out of the 265 days in which they had originally estimated to complete the job.

Journal of the
CONSTRUCTION DIVISION
Proceedings of the American Society of Civil Engineers

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Note.—This paper is a part of the copyrighted Journal of the Construction Division, Proceedings of the American Society of Civil Engineers, Vol. 86, No. CO 2, May, 1960.

ENGINEERING EDUCATION AND THE CONSTRUCTION INDUSTRY: MODERN TRENDS IN CONSTRUCTION ENGINEERING EDUCATION[a]

Closure by Robert L. Schiffman

ROBERT L. SCHIFFMAN,[1] M. ASCE.—The author appreciates the stimulating discussions of Mr. Hershleder and Mr. Howard. Mr. Hershleder seems to believe that a graduate of an "engineering science" curriculum would have difficulty entering the profession without additional training. He further states that if the trend in engineering education is as the author predicts then "the construction industry and consulting offices had better prepare themselves for this condition."

It is the author's opinion that Mr. Hershleder is completely correct in his opinions. One might ponder why such a program, as proposed by the author is "astounding in its import." In this writer's opinion, the answer lies in the relation between the educator and the practicing engineer. For many years civil engineering education has been strongly influences by a vocal portion of the profession who demand that civil engineering graduates be capable of "useful" work almost immediately upon entering the profession. In the opinion of this writer, this portion of the profession fails to appreciate the great changes that are occuring in our technology as a whole, and is still clinging to concepts that prevailed several decades ago. Fortunately this group is dwindling in size year by year, as more and more people realize the obvious. Let us hope that it will shortly cease to exert any influence on the profession.

Mr. Hershleder quite correctly requests details and justifications of a projected general engineering curriculum. Instead of dealing in the future this writer would like to detail a civil engineering curriculum that, in his opinion, should replace the relatively standard curriculum that is currently in vogue. The justification for such a series of courses is the progmatism that new and different problems face the civil engineer and he should be capable of handling them. A few simple examples in the structural field are those involving nuclear power sources, and dynamic and transient heat response of structures.

The curriculum presented on the following pages is set-up by major academic disciplines which are specified in sub-headings.

---

[a] February, 1959, by Robert L. Schiffman.

[1] Asst. Prof. of Soil Mechanics, Rensselaer Polytechnic Inst., Troy, N. Y.

SUBJECT	SEMESTERS
Physics:	
Basic Physics	4
Chemistry:	
Basic Chemistry	2
Physical Chemistry	1
Mathematics:	
Calculus	3
Advanced Calculus	1
Ordinary Differential Equations	1
Boundary Value Problems and Complex Variables	1
Numerical Methods	1
Mathematical Statistics	1
Earth Sciences:	
Physical Geology	1
Geophysics	1
Humanities:	
Four-year Humanities Sequence	8
Drawing:	
Graphics	1
Engineering Sciences:	
Statics and Vector Algebra	1
Dynamics	1
Strength of Materials	2
Fluid Mechanics	1
Mechanical Behavior of Materials	1
Mechanics of Deformable Media	1
Vibrations	1
Electricity and Magnetism	1
Thermodynamics	1
Heat Transfer	1
Metallurgy	1
Civil Engineering:	
Theory of Structures	1
Indeterminate Structures	2
Reinforced Concrete	1
Principles of Structural Design	1
Soil Mechanics	1
Surveying and Engineering Measurements	1
Transportation and Traffic Analysis	1
Sanitary Engineering	1
	47

As a rough measure, if each of the above courses was allocated three credit hours, the total in four years would be 141 credit-hours of instruction. This is on the low side of the average four year civil engineering curriculum.

The author believes that the above curriculum suits today's needs for civil engineers. It is not designed for the technician who can jump from the classroom to the drawing board or to being an inspector and never rise much beyond this point. This curriculum is designed for the man who, in two to five

years after graduation, will be solving new and challenging non-routine problems, without the legalistic and paternal bonds of codes and archaic practices. This man will be, in the true sense, an engineer.

The proposed curriculum is for the present. What about the future? At our present rate of national technological growth the complexity of engineering problems will shortly make our present concept of professions as out-moded as the horse-drawn dump wagon.

At this point we will, by necessity, have to educate engineers in such broad fields that a four or five year program will not be sufficient to give the necessary technical background for anticipated professional competence. As a result, engineering education will become a graduate professional education even as law or medicine is.

At this stage pre-engineering can follow one or two paths. In the first, the entering student will have previously achieved a Bachelor of Science degree with a major in either physics, chemistry, mathematics or biology. The graduate professional education would then concentrate on professional subjects with full background in the pure sciences assumed. Naturally, the undergraduate course would be a direct influence on the professional schooling. Furthermore, there will probably be a reorientation of the professions, away from the traditional lines towards lines of inter-disciplinary congeniality. Thus the future structural engineer will be equally at home in analyzing buildings, as well as machine parts or space vehicles. This of course means that the graduate professional curriculum must be established without the encumbrance of preconceptions of a particular profession.

The second pre-engineering alternative is a common or "engineering science" course for all students seeking to enter the graduate professional schools. This would be very much like the curriculum previously outlined for the modern civil engineer. The major difference would be the replacement of the nine civil engineering courses with a heavier emphasis in the sciences. The major additions would come in the area of chemistry, Particle Physics and Biology, with some additions in Electricity and Magnetism, and Optics.

If the above is in the future, as the author firmly believes, then the pertinent question in this discussion is how does this program suit the needs of the construction industry. The construction industry is no exception to industry's need for educated manpower. It should not be denied this opportunity.

It is true that there is a continuing need for the technician in our profession. This need, however, should and can be filled by the growth of the two-year technical schools. The position of the college is not to be usurped. This is the place of the quality student receiving a quality education.

Mr. Hershleder recognizes that there is a "need for systematizing principles and preparing courses and texts which are more than mere complications of manufacturer's design charts." He pleads for time. The construction industry pre-dates biblical times. One wonders how much time is really necessary.

The author's recommendations for a "loop" course are not inconsistent with the plea for a basic education. On the contrary, they are simply a recognition of the proper role of teacher and practitioner. The medical and legal professions have long recognized this separation. When is the engineering profession going to grow up to its responsibilities?

Mr. Howard's comments are well within the author's thinking. He recognizes that practical experience should be gained, not in the classroom, but in

industry. There is certainly no argument with this thesis. The problem is one of convincing a "conservative" industry of the merits of his plan and that its adoption is in the interests of the industry as a whole.

VENTILATED BUILDING FOUNDATIONS IN GREENLAND[a]

Discussion by John A. Pihlainen

JOHN A. PIHLAINEN.[1]—This description of ventilated building foundations in Greenland is a valuable contribution in a field on which little published experience is available. Although a fundamental principle of construction in permafrost areas, that of minimal thermal disturbance, has long been realized, it is only relatively recently that calculated designs based on this principle have been attempted. Although the ventilation of foundations to minimize thawing can be used on many types of foundations, it is readily adaptable to the gravel-pad type of construction.

In assessing the performance of any foundation in permafrost areas, the soil and ice conditions must be known. The information in Fig. III of the paper by Mr. Williams indicates the natural subsoil to be a silty sand with a moisture content of 21.8%. Comparable moisture contents or, more correctly, ice contents, observed in Canada range from 20% to 200%.[2] Normally, the thawing of silty fine sands with low ice contents, such as 20%, does not cause unacceptable foundation settlements unless the relatively small ice contents occur in segregated form. Unfortunately, Mr. Williams has not shown that unacceptable foundation settlements would have occurred on thawing; the successful performance of the gravel pad may therefore be questioned on this aspect. If objectionable settlements will not occur on thawing, then the design of the gravel pad is based more on combating frost action than on the thaw of permafrost. From the information presented, it is not clear which has been the deciding factor.

Mr. Williams has indicated that caution must be exercised in the use of this foundation type in areas of sporadic permafrost and that in such areas the system may not be practical, presumably from an economic point of view. This restriction is accepted but it is further suggested that these limiting factors apply in some areas of continuous permafrost as well.

In the tundra of Greenland and the Canadian Arctic Islands, the thawing index (an approximation of the energy available for thawing) is considerably less than in the forested regions of continuous permafrost further south. Thus even though the insulating properties of gravel are poor, relatively small amounts of granular material are required in such areas in order to prevent disturbance of permafrost under buildings with ventilated foundations. This, combined with

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[a] September, 1959, by Roger H. Williams.

[1] Northern Bldg. Sect., Div. of Bldg. Research, Natl. Research Council, Ottawa, Canada.

[2] "Permafrost Investigations at Aklavik, 1953 (Drilling and Sampling)," by J. A. Pihlainen and G. H. Johnston, Natl. Research Council, Div. of Bldg. Research, NRC 3393, Ottawa, Canada, January, 1954.

the fact that in Canada granular materials are generally more common in the tundra than in forested regions, suggests the gravel-pad type of foundation to be economic in these areas of the Far North.

It is interesting to note that surface air temperature observations from 1946 to 1949 at Thule[3] show the thawing index to be approximately 555 degree days and not 1960 degree days as shown in Fig. III. The difference in these values is of sufficient magnitude to affect many aspects of the design and performance of the structures described.

In contrast, the thawing index may vary from 2000 to 3000 degree days in the forested regions of continuous permafrost; this necessitates much thicker gravel pads under buildings if disturbance of permafrost is to be avoided. The greater difficulty of locating and utilizing gravel further complicates the use of the gravel-pad type of foundation and may well result in its being uneconomical in these areas. There is a danger in the design of foundations for this forested region of overlooking the increased energy of seasonal thaw over the tundra region since observed seasonal depths of thaw are often similar in both areas. This may be attributed to the exceptional insulating qualities of the mantle of living vegetation and peat, commonly known as "muskeg," that covers most of the forested regions of continuous permafrost. Because of its extremely high thermal resistance, greatly assisted by its ability to retain large quantities of water, variations in the energy of seasonal thaw are not reflected in a varying depth of thaw; in many cases the depth of thaw is confined to the vegetative cover.

During construction, it is difficult to preserve this natural form of insulation and the result is a substantial increase in the depth of thaw. For example, at Inuvik, N.W.T., an area under natural conditions maintained a 2-ft depth of thaw but after the stripping of 12 in. to 18 in. of living vegetation and peat, the depth of thaw in the underlying granular material increased during the following summer to 8 ft. The introduction of a gravel-pad type of foundation in such an area would therefore require as much caution as in areas of sporadic permafrost.

Mr. Williams has suggested that, from thermal and frost action considerations, an ideal pad would be one saturated with water but that the cost of construction involved makes this impractical. Before accepting this suggested improvement to the gravel pad type of foundation, it may be useful to review briefly the function of a gravel pad.

Where thawing of the perennially frozen ground produces little or no volume change, the function of a gravel pad supporting any type of structure would be to arch over small-scale settlements due to minor material changes. Where the thawing of subsurface material will probably produce significant settlements, however, the function of the gravel pad is to insulate so that the resultant thaw produces only settlements that can be accommodated by the arching action of the granular pad. The introduction of a structure introduces additional heat loads which must be dissipated by ventilation and/or balanced by the insulation of additional gravel fill.

It is suggested that an approach to achieving an approximation to an ideal pad having high thermal resistance, an arching property, and yet one nonsusceptible to frost action might be to introduce into the gravel above the ground surface layers of peat (or any material with good water retention prop-

[3] "Climatological Summary, Thule, Greenland," U. S. Dept. of Commerce, Weather Bur., Washington, D. C., 1950.

erties). Since these potentially frost-susceptible materials are in a closed system, they could substantially improve the poor thermal properties of gravel without the danger of frost action. Such a method has been used extensively in Norwegian railroad construction although in a reverse situation to decrease depth of frost penetration into the rail bed.[4] If this type of pad was successful, it would reduce the amount of gravel that is necessary; then perhaps the pad type of construction might become economically feasible in the forested areas of continuous permafrost.

4 "Protection Against Frost Heaving on the Norwegian Railways," by Sv. Skaven-Haug, Geotechnique, Vol. IX, No. 3, September, 1959, pp. 87-106.

PROCEEDINGS PAPERS

The technical papers published in the past year are identified by number below. Technical-division sponsorship is indicated by an abbreviation at the end of each Paper Number, the symbols referring to: Air Transport (AT), City Planning (CP), Construction (CO), Engineering Mechanics (EM), Highway (HW), Hydraulics (HY), Irrigation and Drainage (IR), Pipeline (PL), Power (PO), Sanitary Engineering (SA), Soil Mechanics and Foundations (SM), Structural (ST), Surveying and Mapping (SU), and Waterways and Harbors (WW), divisions. Papers sponsored by the Department of Conditions of Practice are identified by the symbols (PP). For titles and order coupons, refer to the appropriate issue of "Civil Engineering." Beginning with Volume 82 (January 1956) papers were published in Journals of the various Technical Divisions. To locate papers in the Journals, the symbols after the paper number are followed by a numeral designating the issue of a particular Journal in which the paper appeared. For example, Paper 2270 is identified as 2270(ST9) which indicates that the paper is contained in the ninth issue of the Journal of the Structural Division during 1959.

VOLUME 85 (1959)

MAY: 2014(AT2), 2015(AT2), 2016(AT2), 2017(HY5), 2018(HY5), 2019(HY5), 2020(HY5), 2021(HY5), 2022(HY5), 2023(PL2), 2024(PL2), 2025(PL2), 2026(PP1), 2027(PP1), 2028(PP1), 2029(PP1), 2030(SA3), 2031(SA3), 2032(SA3), 2033(SA3), 2034(ST5), 2035(ST5), 2036(ST5), 2037(ST5), 2038(PL2), 2039(PL2), 2040(AT2)[c], 2041(PL2)[c], 2042(PP1)[c], 2043(ST5)[c], 2044(SA3)[c], 2045(HY5)[c], 2046(PP1), 2047(PP1).

JUNE: 2048(CP1), 2049(CP1), 2050(CP1), 2051(CP1), 2052(CP1), 2053(CP1), 2054(CP1), 2055(CP1), 2056(HY6), 2057(HY6), 2058(HY6), 2059(IR2), 2060(IR2), 2061(PO3), 2062(SM3), 2063(SM3), 2064(SM3), 2065(ST6), 2066(WW2), 2067(WW2), 2068(WW2), 2069(WW2), 2070(WW2), 2071(WW2), 2072(CP1)[c], 2073(IR2)[c], 2074(PO3)[c], 2075(ST6)[c], 2076(HY6)[c], 2077(SM3)[c], 2078(WW2)[c].

JULY: 2079(HY7), 2080(HY7), 2081(HY7), 2082(HY7), 2083(HY7), 2084(HY7), 2085(HY7), 2086(SA4), 2087(SA4), 2088(SA4), 2089(SA4), 2090(SA4), 2091(EM3), 2092(EM3), 2093(EM3), 2094(EM3), 2095(EM3), 2096(EM3), 2097(HY7)[c], 2098(SA4)[c], 2099(EM3)[c], 2100(AT3), 2101(AT3), 2102(AT3), 2103(AT3), 2104(AT3), 2105(AT3), 2106(AT3), 2107(AT3), 2108(AT3), 2109(AT3), 2110(AT3), 2111(AT3), 2112(AT3), 2113(AT3), 2114(AT3), 2115(AT3), 2116(AT3), 2117(AT3), 2118(AT3), 2119(AT3), 2120(AT3), 2121(AT3), 2122(AT3), 2123(AT3), 2124(AT3), 2125(AT3).

AUGUST: 2126(HY8), 2127(HY8), 2128(HY8), 2129(HY8), 2130(PO4), 2131(PO4), 2132(PO4), 2133(PO4), 2134(SM4), 2135(SM4), 2136(SM4), 2137(SM4), 2138(HY8)[c], 2139(PO4)[c] 2140(SM4)[c].

SEPTEMBER: 2141(CO2), 2142(CO2), 2143(CO2), 2144(HW3), 2145(HW3), 2146(HW3), 2147(HY9), 2148(HY9), 2149(HY9), 2150(HY9), 2151(IR3), 2152(ST7)[c], 2153(IR3), 2154(IR3), 2155(IR3), 2156(IR3), 2157(IR3), 2158(IR3), 2159(IR3), 2160(IR3), 2161(SA5), 2162(SA5), 2163(ST7), 2164(ST7), 2165(SU1), 2166(SU1), 2167(WW3), 2168(WW3), 2169(WW3), 2170(WW3), 2171(WW3), 2172(WW3), 2173(WW3), 2174(WW3), 2175(WW3), 2176(WW3), 2177(WW3), 2178(CO2)[c], 2179(IR3)[c], 2180(HW3)[c], 2181(SA5)[c], 2182(HY9)[c], 2183(SU1)[c], 2184(WW3)[c], 2185(PP2)[c], 2186(ST7)[c], 2187(PP2), 2188(PP2).

OCTOBER: 2189(AT4), 2190(AT4), 2191(AT4), 2192(AT4), 2193(AT4), 2194(EM4), 2195(EM4), 2196(EM4), 2197(EM4), 2198(EM4), 2199(EM4), 2200(HY10), 2201(HY10), 2202(HY10), 2203(PL3), 2204(PL3), 2205(PL3), 2206(PO5), 2207(PO5), 2208(PO5), 2209(PO5), 2210(SM5), 2211(SM5), 2212(SM5), 2213(SM5), 2214(SM5), 2215(SM5), 2216(SM5), 2217(SM5), 2218(ST8), 2219(ST8), 2220(EM4), 2221(ST8), 2222(ST8), 2223(ST8), 2224(HY10), 2225(HY10), 2226(PO5), 2227(PO5), 2228(PO5), 2229(ST8), 2230(EM4), 2231(EM4), 2232(AT4)[c], 2233(PL3)[c], 2234(EM4)[c], 2235(HY10)[c], 2236(SM5)[c], 2237(ST8)[c], 2238(PO5)[c], 2239(ST8), 2240(PL3).

NOVEMBER: 2241(HY11), 2242(HY11), 2243(HY11), 2244(HY11), 2245(HY11), 2246(SA6), 2247(SA6), 2248(SA6), 2249(SA6), 2250(SA6), 2251(SA6), 2252(SA6), 2253(SA6), 2254(SA6), 2255(SA6), 2256(ST9), 2257(ST9), 2258(ST9), 2259(ST9), 2260(HY11), 2261(ST9)[c], 2262(ST9), 2263(HY11), 2264(ST9), 2265(HY11), 2266(SA6), 2267(SA6), 2268(SA6), 2269(HY11)[c], 2270(ST9).

DECEMBER: 2271(HY12)[c], 2272(CP2), 2273(HW4), 2274(HW4), 2275(HW4), 2276(HW4), 2277(HW4), 2278(HW4), 2279(HW4), 2280(HW4), 2281(IR4), 2282(IR4), 2283(IR4), 2284(IR4), 2285(PO6), 2286(PO6), 2287(PO6), 2288(PO6), 2289(PO6), 2290(PO6), 2291(PO6), 2292(SM6), 2293(SM6), 2294(SM6), 2295(SM6), 2296(SM6), 2297(WW4), 2298(WW4), 2299(WW4), 2300(WW4), 2301(WW4), 2302(WW4), 2303(WW4), 2304(HW4), 2305(ST10), 2306(CP2), 2307(CP2), 2308(ST10), 2309(CP2), 2310(HY12), 2311(HY12), 2312(PO6), 2313(PO6), 2314(ST10), 2315(HY12), 2316(HY12), 2317(HY12), 2318(WW4), 2319(SM6), 2320(SM6), 2321(ST10), 2322(ST10), 2323(HW4)[c], 2324(CP2)[c], 2325(SM6)[c], 2326(WW4)[c], 2327(IR4)[c], 2328(PO6)[c], 2329(ST10)[c], 2330(CP2).

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JANUARY: 2331(EM1), 2332(EM1), 2333(EM1), 2334(EM1), 2335(HY1), 2336(HY1), 2337(EM1), 2338(EM1), 2339(HY1), 2340(HY1), 2341(SA1), 2342(EM1), 2343(SA1), 2344(ST1), 2345(ST1), 2346(ST1), 2347(ST1), 2348(EM1)[c], 2349(HY1)[c], 2350(ST1), 2351(ST1), 2352(SA1)[c], 2353(ST1)[c], 2354(ST1).

FEBRUARY: 2355(CO1), 2356(CO1), 2357(CO1), 2358(CO1), 2359(CO1), 2360(CO1), 2361(PO1), 2362(HY2), 2363(ST2), 2364(HY2), 2365(SU1), 2366(HY2), 2367(SU1), 2368(SM1), 2369(HY2), 2370(SU1), 2371(HY2), 2372(PO1), 2373(SM1), 2374(HY2), 2375(PO1), 2376(HY2), 2377(CO1)[c], 2378(SU1), 2379(SU1), 2380(SU1), 2381(HY2)[c], 2382(ST2), 2383(SU1), 2384(ST2), 2385(SU1)[c], 2386(SU1), 2387(SU1), 2388(SU1), 2389(SM1), 2390(ST2)[c], 2391(SM1)[c], 2392(PO1)[c].

MARCH: 2393(IR1), 2394(IR1), 2395(IR1), 2396(IR1), 2397(IR1), 2398(IR1), 2399(IR1), 2400(IR1), 2401(IR1), 2402(IR1), 2403(IR1), 2404(IR1), 2405(IR1), 2406(IR1), 2407(SA2), 2408(SA2), 2409(HY3), 2410(ST3), 2411(SA2), 2412(HW1), 2413(WW1), 2414(WW1), 2415(HY3), 2416(HW1), 2417(HW3), 2418(HW1)[c], 2419(WW1)[c], 2420(WW1), 2421(WW1), 2422(WW1), 2423(WW1), 2424(SA2), 2425(SA2)[c], 2426(HY3)[c], 2427(ST3)[c].

APRIL: 2428(ST4), 2429(HY4), 2430(PO2), 2431(SM2), 2432(PO2), 2433(ST4), 2434(EM2), 2435(PO2), 2436(ST4), 2437(ST4), 2438(HY4), 2439(EM2), 2440(EM2), 2441(ST4), 2442(SM2), 2443(HY4), 2444(ST4), 2445(EM2), 2446(ST4), 2447(EM2), 2448(SM2), 2449(HY4), 2450(ST4), 2451(HY4), 2452(HY4), 2453(EM2), 2454(EM2), 2455(EM2)[c], 2456(HY4)[c], 2457(PO2)[c], 2458(ST4)[c], 2459(SM2)[c].

MAY: 2460(AT1), 2461(ST5), 2462(AT1), 2463(AT1), 2464(CP1), 2465(CP1), 2466(AT1), 2467(AT1), 2468(SA3), 2469(HY5), 2470(ST5), 2471(SA3), 2472(SA3), 2473(ST5), 2474(SA3), 2475(ST5), 2476(SA3), 2477(ST5), 2478(HY5), 2479(SA3), 2480(ST5), 2481(SA3), 2482(CO2), 2483(CO2), 2484(HY5), 2485(HY5), 2486(AT1)[c], 2487(CP1)[c], 2488(CO2)[c], 2489(HY5)[c], 2490(SA3)[c], 2491(ST5)[c], 2492(CP1), 2493(CO2).

c. Discussion of several papers, grouped by divisions.

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PART 2

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Your attention is invited

NEWS OF THE CONSTRUCTION DIVISION OF ASCE

JOURNAL OF THE CONSTRUCTION DIVISION
PROCEEDINGS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS

DIVISION ACTIVITIES
CONSTRUCTION DIVISION

Proceedings of the American Society of Civil Engineers

NEWS

May, 1960

MEMO FROM CONSTRUCTION DIVISION CHAIRMAN

Lyman D. Wilbur, chief engineer of Morrison-Knudsen Co. who succeeded Walter L. Couse as chairman of the Construction Division Executive Committee last November, has addressed a short but important message to all Construction Division members.

"Dear Fellow CD Members:

For ASCE to do its best work, it is desirable that all engineers who qualify become members of the Society. A friendly personal invitation to a fellow engineer could well arouse his interest in Society activities. Because of the frequent moves of a construction man, it is perhaps more difficult for him to become active in the Society than for members in any of the other divisions. However, I am sure that if each one of you contacted a non-member in your own organization, you would find many that would welcome the opportunity to join the Society or to again become active in its program. Why don't you invite your associates to join the Society and its Construction Division?"

Lyman D. Wilbur

CONSTRUCTION RESEARCH IDEAS SOUGHT

If, as many claim, the civil engineering field lags most other engineering disciplines in efforts expended on research, then the construction engineering research phase of civil engineering has the unenviable distinction of bringing up the rear. It is the aim of William W. Moore's CD Committee on construction Research to make a frontal attack on the situation. First step is the gathering of thoughts and ideas on subjects for research from CD members at large.

Note.—This paper is a part of the copyrighted Journal of the Construction Division, Proceedings of the American Society of Civil Engineers, Vol. 86, No. CO 2, May, 1960.
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Mr. Moore emphasizes that subjects for research exist in the area of construction managerial procedures as well as construction materials and technical procedures. CD members are cordially invited to express their thoughts to Mr. Moore, c/o Dames and Moore, 340 Market St., San Francisco, Calif.

The CD Research Committee has no funds at its disposal to carry out research projects; rather it will attempt to initiate, instigate and promote research by other agencies.

CD COMMITTEE TO REVISE BUILDING SAFETY CODE

The CD Committee on Construction Standards has begun a complete revision of the American Standard Safety Code for Building Construction.

Under the guidance of chairman Warren S. Mann, committee members Harold E. Bisbort, Miles N. Clair, James B. Diven, Jr. and Eugene F. Gibbons have each taken several sections of the old code under their personal charge. As sections are revised they will be circulated among other committee members and outside authorities for comment.

The committee reached the decision to completely revise the safety code primarily because of the current code's age. It is nearly 20 years old and many of its text references are 20 to 25 years old and have been largely superseded. In addition, many new developments in methods, material and equipment are not covered at all.

In the revised building safety code, the committee contemplates these improvements in format and organization.

. All sections will follow an identical format to enable users to find information more easily.

. Text pertaining to routine maintenance will be eliminated (except when related to a safety hazard).

. References to other codes will be avoided. Where the material is of importance, it will be included in its entirety in the revised American Standard Safety Code for Building Construction. The intent is to make the new code complete in itself, to better serve the field man who can hardly be expected to have a full library on hand.

. By circulating the edited sections to a cross section of members and other authorities all over the country, it is hoped the new code can be made to conform to the conditions in all geographical areas.

SAN FRANCISCO CD MEETINGS WELL ATTENDED

The Construction Division of the San Francisco Section reports continued heavy and enthusiastic attendance at meetings. Attendance regularly exceeds 80 persons, which the "management" attributes to three policies: (1) Careful selection of speakers; (2) wide publicity, and (3) no business meeting.

Particularly successful meetings during the last year featured convivial heavy construction anecdotes by Francis J. Murphy, vice president and general manager of Yuba Consolidated Erectors, Inc. and a panel discussion of construction management. Panel members were Stanford University's Clark Oglesby, Guy F. Athhinson's assistant general manager Grant Gordon, and Len Waldo, management consultant.

The "management" of the SF CD consists of Joseph Kaplan, chairman; Edward Schulhauser, vice-chairman; and Richard Lowell, secretary-treasurer.

HOW THE THROGS NECK SUSPENSION BRIDGE IS BEING BUILT

One of the year's outstanding construction talks was given last winter before the Metropolitan Section by Nomer Gray, Ammann & Whitney partner in charge of the firm's construction supervision activities. Mr. Gray knowingly described the foundation construction of the Throgs Neck Bridge, a suspension structure that will roughly parallel the Bronx-Whitestone Bridge across Long Island Sound in New York City.

The keynote of the talk was that unlike most other civil engineering structures, the method of construction of the huge foundations for a suspension bridge determines, in large part, their design. Also contributing to the success of the talk was Mr. Gray's facility in talking at two levels almost in the same breath. While he made the presentation understandable at the general engineering level, there was still much of interest to the foundation expert.

ADVERSE WEATHER PROBLEMS, SOLUTIONS SOUGHT

The CD Committee in Adverse Weather Conditions will appreciate receiving information on Dry Cold, Wet Cold, Dry Hot and Wet Hot from members of the Construction Division. The Committee seeks either problems and solutions or any other type of information that would be of interest.

Captain Palmer W. Roberts (CEC, USN), committee chairman, suggests that CD members write directly to the sub-committee chairman of the specific area concerned, to wit:

Dry Cold Conditions--Capt. T. Herbert Whitney, Bureau of Yards and Docks, Washington 25, D. C.

Wet Cold Conditions--James Brannian, 5806 North Monroe St., Spokane 19, Wash.

Dry Hot Conditions--N. E. Manasseh, American University of Beirut, Faculty of Engineering, Beirut, Lebanon.

Wet Hot Conditions--Cesar S. Canals, Frederick Snare Corp., 233 Broadway, New York 7, N. Y.

ARTIC ENGINEERING

A technical publication, prepared by the Bureau of Yards and Docks of the U. S. Navy, has recently been made available to the public and may be procured from the Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C., at a cost of $6.00. This 473-page document will be valuable to all those engineers and construction firms who are interested in working in cold regions. This publication, which is divided into four chapters, provides guidance to Bureau and field personnel engaged in the planning, design, construction, alteration, repair and maintenance of facilities in areas of extremely low temperatures.

CONTRACT DOCUMENTS COMMITTEE ACTS

At a meeting of the Contract Documents Committee in Chicago in January, the principal order of business was a review of the ASCE-AGC Form of Contract in the light of a cross-section of experience and opinion which had been developed during the previous year from leading engineers and contractors all over the Country. A resolution was passed requesting that publication of the 1960 edition of the ASCE-AGC Form of Contract be postponed pending the Committee's report following the meeting.

It also was agreed that the Committee should recommend representation of ASCE in all groups working in this field. The work being done by the Construction Specifications Institute was selected as the first in this program. It also was agreed that the Committee recommend that its own functions should include that of being a clearing house and a source of advice for ASCE representatives on these various groups.

MISCELLANY

The chairman of the CD Publications Committee, M. D. Morris, calls attention to a paper worthy of CD Member note in another ASCE Journal. It is "Pile Construction in Permafrost" by J. A. Pihlainen in the Journal of the Soil Mechanics and Foundations Division (vol. 85, No. SM6, December, 1959). Mr. Morris is the author of a current series of articles on "Earth Compaction-How to Achieve Better Results at Less Cost" in Construction Methods & Equipment.